Theme 1
Property level and scalable solutions

Relevant expressions of interest in attending the workshop **(Where do you think the research frontiers are around addressing current and likely future built environment challenges?)**
• Flexible buildings able to change use according to need -resilience and design for assembly/disassembly; • Considering future technological developments, population growth, urban climate etc. under consideration when designing new buildings in the urban environment. • Research on the performance of technologies and other interventions, in mass deployment, particularly to achieve an understanding of performance in the context of socio-technical factors in the supply chain, and during building occupation. • Building in preparedness to design and management of buildings for tackling the challenges society faces especially hot weather & heatwaves. • Understanding occupant behaviour to inform design of environmental systems in buildings • Material science –preventing infections through materials and ventilation • Reducing error in construction. • The creation of high quality, resilient buildings and infrastructure needs us to move away from prescriptive design processes towards true performance based design; where the actual performance matches specified/required performance; where the material and energy inputs are appropriate, not excessive • Other engineering disciplines, such as mechanical and aerospace, have embraced the embodiment of intelligence into their structural systems. Time for or advanced smart technologies to be incorporated into the built environment as a matter of routine for performance monitoring and enhancement, with a view to increasing life expectancy, reliability and, most importantly, sustainability. • Further evidence gathering and research around comfortable temperatures for sleeping in the UK; Ability to model additional effects not currently accounted for in dynamic thermal simulation, thermal boundary layers and impacts for building ventilation + passive & low energy ventilation solutions

Property level and scalable solutions

Session #1 [pre-assigned –might include some unable to attend on the day]

- Abigail Hathway
- Anastasia Mylona
- Francesco Pomponi
- Gráinne McGill
- Guogang Ren
- Messaoud Saidani
- Paul Reynolds
- Peter Winslow
- Rajat Gupta
- Ranald Lawrence
- Robert Lowe
- Sarah Lindeman
- Susan Roaf
- Valeria Branciforti
- Zoe Fitzgerald

Session #2 [self-selected]

- Anastasia Mylona
- Graham Leeks
- Jessica Lamond
- John Dover
- Lynne Jack
- Martin Field
- Steve Evans
- Udeshika Weerakkody
- Valeria Branciforti

VISION: What does the built environment of a productive, connected, resilient, healthy nation look like in 2080?

Table number 1b

- How buildings may be built → robotics etc
- 100% accuracy in the built env.
- Effective retrofitting for culturally/socially important builds
- More from generic buildings to aesthetic and functionality in buildings to suit individual needs in terms of health, wellbeing etc.
- Community ownership
- Ability to adapt and maintain in Zero Carbon
- Accessible + inclusive
- Wellbeing as a driver

Theme 2
Built environment as a living system, interdependencies with supporting infrastructure

Relevant expressions of interest in attending the workshop

(Where do you think the research frontiers are around addressing current and likely future built environment challenges?)

- The development and conceptualization of space and time. Space in terms of how we use space, how we create space, how much space we need, how different people perceive different spaces - and how can we provide the infrastructure to serve the spaces we need. With the increasing population these questions seem most urgent. The second dimension, time, mostly relates to the question how our growing awareness of uncertainties can be implemented into (planning and development) practice.
- Designing buildings as part of cities and their infrastructure
- The future requires cities that are more adaptable to various drivers of change, and within different timescales.
- Low-cost distributed sensing & distributed sensor networks, have the potential to revolutionise the speed and reliability at which we design-built-test-learn-repeat. Understanding how real building structures behave and real internal environmental performance will enable continuous reductions in resource use in construction and improve health and well-being.
- Designing in, not out, climate refugees, to buildings, neighbourhoods and cities
- Identifying, understanding and addressing the risk of unintended consequences of climate change mitigation, including:
    1. Risk of poor indoor air quality.
    2. Risk of overheating and
    3. .Risk of moisture problems
- Integrated building and urban design for sustainable built environment; Smart built environment for aging population
- Consideration of water and energy required to extract, process, transport and build houses made from current industry recognised materials like steel, concrete and polymers
- Use and development of technologies (e.g. ICT) to automate construction and to addresses pressing issues (e.g. waste and occupational health and safety) in the construction process.

- The influence of indoor environmental quality on climate-related morbidity and mortality and, in particular, the potential modifying effect of building fabric characteristics on adverse health effects, is a relatively under researched area to date. It is essential to quantify the impact of building attributes on individual exposure to temperature and pollution-related health risks. It is also essential to translate academic research outcomes into user-friendly tools for the improvement of public health outcomes in the UK.
- Innovation in infrastructure sectors (in particular energy sector) is likely to lead to more differences in built environment than currently exist.. It is imperative how these forces mutually influence and shape each other to ensure that costs and benefits are borne equitably.
- Using advances in 'Big Data' and parallel/distributed computing it is becoming possible to model proposed changes across a detailed model of the building stock (and the land around the buildings). The interactions between buildings, road networks and the available land can provide new density indicators paving the way for 'smarter' future energy solutions
- Research needs to focus on improving resource efficiency and building infrastructure capable of withstanding both increasing numbers of people and the impacts of climate change. An aspect that has been neglected thus far are the pathways in which infectious disease spreads within the built environment affecting the health of the inhabitants. Population growth and climate change will directly impact this issue.
- To address multiple concurrent challenges, frequently exacerbated by social deprivation and inequality found in many urbanised areas, a whole systems approach is required, addressing regeneration with a social agenda, energy efficiency, health and well-being, and community engagement within an environmentally sustainable system, which goes beyond lip-service but is based on collaboration between the different disciplines.
- Systemic modelling and assessment of future post-carbon building environment.

Built environment as a living system, interdependencies with supporting infrastructure

Session #1 [pre-assigned –might include some unable to attend on the day]

- Chris Baker
- Rachel Capon
- Lena Ciric
- David Coley
- Stephen Evans
- Athanasios Kourniotis
- Zhiwen(Vincent) Luo
- Patrick Manu
- Anna Mavrogianni
- Marialena Nikolopoulou
- Nazmiye Ozkan
- Sagar A Sumaria
- Helena Titheridge
- Erin Walsh
- Udeshika Weerakkody
- Yangang Xing

Session #2 [self-selected]

- Abigail Hathway
- Chris Noyce
- David Jenkins
- Elle Atkins
- Helena Titheridge
- Lena Ciric
- Marialena Nikolopoulou
- Vincent Luo
- Zoe Fitzgerald

VISION: What does the built environment of a productive, connected, resilient, healthy nation look like in 2080?

Table number 2a

- We should be zero-carbon society
  - Happy, healthy people & pollution-free environment
  - Population characteristics - ageing vs low birth rates.
  - we don't know!
  - inertia in built environment -

VISION: What does the built environment of a productive, connected, resilient, healthy nation look like in 2080?

Table number 2b

[From back: 'Meeting air pollution guidelines (EU)]

Understanding the value of green infrastructure (eg Living Walls) eg benefits
- outdoor air pollution
- indoor living walls
- biodiversity aspects

Preserving the heritage/aesthetic AND modernising?

Solving issues: eg planning restrictions; disconnect between land (ownership, cost), designing & developing buildings, business models, use, educated consumers

Multifunctional buildings but not over-engineered: what do people need.

Disruptive technologies eg in transport - Autonomous vehicles blurring public/private models, ~~blurring~~ subverting what a transport interchange is in relation to buildings' functions - eg driving right into the mall (no tail pipe emissions)

Healthy: limiting spread of diseases, reducing pathogen load: role of education of consumers & building users (applies to energy & waste) understanding how to use the buildings for their designed efficiency (note: energy efficient homes could be unhealthy)

PT

Theme 3

What lies beneath (urban soil resilience, groundwater, geo-environmental engineering)

Relevant expressions of interest in attending the workshop **(Where do you think the research frontiers are around addressing current and likely future built environment challenges?)**
• In depth understanding of future green- grey infrastructure interaction for resilient buildings, including understanding urban soil moisture, fungi • Resilience pathways of urban drainage infrastructure • Urban water innovation is needed to ensure greater resource efficiency and savings, better management and control, reduced emissions and point source/diffuse pollution, risk prevention and adaptation, improved knowledge and data collection and promotion of a more sustainable management culture • Extending life of materials forming structures underground and underwater • The challenge lies in understanding the complex processes of how the key elements (water, air, soil, energy etc.) are inter-connected in the built environment, understanding the cascaded risks of infrastructure systems, and identifying resilient adaptation measures to future uncertainties. • The interactions, interdependencies and feedbacks between the green-grey- blue infrastructure of urban systems, producing a flow of ecosystem services and coupled to the Five Capitals: Natural; Human; Social; Manufactured and Financial.

Grey literature	**Source**
• Impact of infiltration on capacity • Addressing pollution from combined sewer overflows • Robust rainfall and drought models to enable water companies to test their systems	Defra – Enabling water resilience in the water sector
• Natural capital to built capital, whilst preserving natural resources for future generations • Can we engineer multifunctional urban soils for climate change adaptation and mitigation • Building soil resilience	EAC – Report on soil health
• Exploitation of soils to enhance sustainability and resilience of cities	Royal Society of Chemistry –securing soils for sustainable agriculture

What lies beneath
(urban soil resilience, groundwater, geo-environmental engineering)

Session #1 [pre-assigned –might include some unable to attend on the day]

- Bingunath Ingirige
- Guangtao Fu
- Jess Davies
- Jim Harris
- Li Shao
- Michael Green
- YK Cheong
- Zoran Kapelan

What lies beneath
(broader definition used)

Session #2 [self-selected]

- Li Shao
- Jacqueline Glass
- Sabine Pahl

VISION: What does the built environment of a productive, connected, resilient, healthy nation look like in 2080?

Table number 3

- GREATER UNDERSTANDING AND DESIGN FOR PEOPLE NEEDS
- WIDER USE OF DIFFERENT SMART TECHNOLOGIES INCREASING THE QUALITY OF LIFE IN BUILT ENVIRONMENT
- GREATER INTEGRATION WITH SURROUNDING NATURAL ENVIRONMENT AND INFRASTRUCTURE
- BETTER FLOOD-PROOFING (WHERE NECESSARY)
- MOVE TOWARDS MORE FLEXIBLE AND ADAPTIVE USE OF BUILT ENVIRONMENT (VIA MULTI-PURPOSE USE - EG SUDS)
- WHO PAYS FOR SUDS / GREEN INFRASTRUCTURE
- IMPROVED NEXUS OF WATER, ENERGY - FOOD IN THE BUILT ENVIRONMENT
- IMPROVED USE OF BROWNFIELDS

Theme 4
Ageing built environment and supporting infrastructure

Relevant expressions of interest in attending the workshop

(Where do you think the research frontiers are around addressing current and likely future built environment challenges?)

- Looking at lifecycle issues affecting buildings
- New and existing building stock has to contend with the needs of older people, changes in service provisioning (including energy) and the impacts these have on occupants' health and safety and the wider implications for local services.
- Our understanding of buildings as part of a wider infrastructure system is poor. Some examples of challenges might include:
    - How to create reliable systems with unreliable components•
    - How to design infrastructure systems to adapt to cascading failures
    - Bolting together legacy with new systems
    - Handling significant variations in sub-system evolution - handling the Red Queen effect
    - Designing Infrastructure Systems to exhibit certain probability distributions of behaviour.
    - Understanding Infrastructure Interdependencies across systems, scales and components.
    - Spotting unusual behaviour, particularly in cases where we have lots of data but very little failure to go on.
- A sustainable answer to rapid urbanisation. Mainstreaming of business cases for sustainable built environment beyond CSR. Enabling building adaptation and retrofit at low cost.
- Designing and reconfiguring
    - built environment systems to handle multiple overlapping shocks and stresses.
    - buildings to act as active agents in advanced smart grids
- Decarbonising heat within the constraints of the power network (inter-seasonal storage, local network stresses etc. where and using what technology should storage be?)
- Embodied carbon; solutions for the existing building stock
- Tackling the increased strain on the distribution network to cope with larger and more uncertain demands.
    - Plug and play for inbuilt flexibility
    - Connectivity with local energy markets.
- Optimising local mix across energy vectors.

Ageing built environment and supporting infrastructure

Session #1 [pre-assigned –might include some unable to attend on the day]

Alice	Moncaster
Dana	Abi Ghanem
Francesca	Medda
John	Kamara
Judith	Ward
Loretta	von der Tann
Martin	Mayfield
Stephen	Haben

Session #2 [self-selected]

- Anna Mavrogianni
- Bob Lowe
- Patrick Manu

VISION: What does the built environment of a productive, connected, resilient, healthy nation look like in 2080?

Table number 4

Adaptable buildings
- materials for reuse
- design in for new build

Protected heritage
- tools to support decisions to demolish/adapt existing buildings

Circular economy
- anticipate, plan for future energy technologies & uses

Flexible and connected
- connect and disconnect to changing and interrupted infrastructure services

Anticipatory, learns behaviour - true smart grid

Infrastructure and buildings both mutually evolving to adapt to new needs, climates & energy uses.

Theme 5

Preparing society and industry (consumers, markets and industry interactions)

Relevant expressions of interest in attending the workshop **(Where do you think the research frontiers are around addressing current and likely future built environment challenges?)**

• Understanding the social, cultural and political confluences impact the rate of uptake of new technologies and how the rate of uptake impacts on resilience of our infrastructure systems and communities.
• Need for better tools to help with future visioning and testing of the resilience of future pathways to change and disruption.
• Being able to move beyond a dominance by any one discipline or profession in how built settings are planned and evaluated.
• understanding home owners, space heating delivery and energy storage systems: matching the right technical options with peoples lifestyles and enabling control flexibility to match comfort demand with energy and pricing constraints.
• Need radical interdisciplinary approaches to tackle well-know, wicked problems. We should be tackling the biggest challenge and that is the user/consumer (by which I include building actors, designers, specifiers, contractors etc), because change is too slow, particularly in response to climate change and environmental risks.
  ○ What are the most effective ways to enact change in user/consumer behaviour?
  ○ Can we use modelling to predict this?
  ○ Do underlying personal values have a role to play?
  ○ What are the inherent features of our built environment procurement model which prevent change?
  ○ Is our unit of analysis correct - or should we more flexible in how we undertake research?
• Greater integration of the behavioural sciences and technological approaches; integrating healthy living and carbon reduction more systematically; evaluating large-scale programmes ideally working towards randomised controlled trials
• Changes in climate and in living and working patterns and social environments change mean that built environment research requires multidisciplinary approaches that encompass the socio-technical nexus.
• Understanding the role of technology in facilitating enhanced living conditions for all and in meeting sustainability targets has to be matched with fundamental improvements in engineering design and practice that meets social and cultural expectations.

- As a public people within the UK do not have cause yet to realise the deleterious conditions that may ensue with future climate changes and pollution and population pressures that will impact future urban life. It may be a ‘it’ll never happen to us’ attitude as these conditions are more in the forefront in other countries. The frontiers we need to address are to provide evidence to demonstrate the threats and the possible solutions to future problems to increase understanding; not just within government and academia, to try and educate the voters ensuring governments provide legislation, as in other countries, of the requirements of future built landscapes.

Preparing society and industry
(consumers, markets and industry interactions)

Session #1 [pre-assigned –might include some unable to attend on the day]

- Eleanor Atkins
- Jacqueline Glass
- Jessica Lamond
- Martin Field
- Riccardo Russo
- Richard Buswell
- Sabine Pahl
- Vitas Kris

Amended in the workshop to:
Preparing research to respond to the needs of society and industry
(communities, residents, consumers, markets and industry interactions)
in dialogue & partnership

Session #2 [self-selected]

- Alice Moncaster
- Jane McCullough
- Kate Pangbourne
- Nick Jackson
- Paul Reynolds
- Pete Winslow
- Sara Lindeman
- Sarah Bell

VISION: What does the built environment of a productive, connected, resilient, healthy nation look like in 2080?

Table number 5

It has a new type of building, less dependent on central infrastructure ← water, food etc

It is determined by people - taking wellbeing, happiness, connectedness, ageing into account.

It is bottom-up, adaptable (modular).

It has social and natural spaces -

It is self-sustaining (food etc) multi-functional.

← this is central to it.

It meets changing resource needs, and is circular (recycling)

All Buildings operate to / meet climate change requirements (zero carbon / zero energy reqs).

It has a local focus - transport
waste
access to facilities
access to work

It may have different transport + automation mechanisms (eg personal vehicles etc)

GAME CHANGER Table number 1A

Title: EPSRC driven by Wellbeing not Productivity

Detail

→ Indirect driver no longer UK GDP growth, but human wellbeing

GAME CHANGER Table number 1A

Title: Effectively linked TRL1-9

Detail

currently a huge gap between TRL 1-3 (university) and TRL 8-9 (industry) means R&D benefits very slow/don't occur in practice in 99% of construction/built environment

GAME CHANGER Table number 1a

Title: FLEXIBILITY IN BUILDINGS

Detail

- HOW PHYSICAL ENVIRONMENT WILL BE ADAPTED FOR PERSONAL/SOCIAL NEEDS?
- SOME BUILDING TYPES SUCH AS OFFICES MAY CHANGE?
- FLEXIBILITY IN USE OF ENERGY

GAME CHANGER Table number 1a

Title:

Detail Climate change, impacts of mass migration. Developing adaptation strategies + trajectories for existing buildings in progressively warmer world

GAME CHANGER Table number 1a

Title: NUCLEAR FUSION

Detail

SAFE, RELIABLE, POTENTIALLY UNLIMITED 'ZERO CARBON' ENERGY

EFFICIENCY MAY BE DRIVEN BY COST RATHER THAN CARBON

GAME CHANGER Table number 2a

Title: Climate Change Mitigated!

Detail

Agenda moving from CO_2 reduction to other issues

GAME CHANGER Table number 2a

Title: Teleportation!

Detail

Changes completely (perhaps) our need to congregate in urban areas.

GAME CHANGER Table number 2a

Title: Buildings becoming more self sustaining.

Detail

Energy generation requirement on each building reducing the requirement to bring energy in from long distances away.

Buildings required to manage their own wate

GAME CHANGER Table number 2b

Title: TECHNOLOGY IS OUR SLAVE NOT OUR MASTER

Detail

We are not being driven by technology, instead of technology driving how we live and society.

GAME CHANGER Table number 2b

Title: Autonomous systems & vehicles

Detail

Seriously disruptive for parking, transport infrastructure, active travel, distances between destinations buildings/activities...

GAME CHANGER Table number 3

Title:

Detail IMPROVED UNDERSTANDING OF WATER-ENERGY-FOOD-OTHER NEXUS IN THE BUILT ENVIRONMENT AND UTILISATION OF THIS TO IMPROVE THE METABOLISM OF THIS ENVIRONMENT

GAME CHANGER Table number 4

Title: Reversing Climate Change and Nuclear Fusion

Detail

might be science fiction but can change the rules of the game in terms of resilience and adaptability.

Buildings will have to adapt to geo-engineering.
e.g. "CO_2 sequestering BE"

GAME CHANGER Table number 4

Title: Carbon dioxide reduction

Detail = (Clean energy producer).

- Solar panels on Space elevators.
- pumping Carbon Dioxide to Space.

GAME CHANGER Table number 4

Title: Completely circular built environment

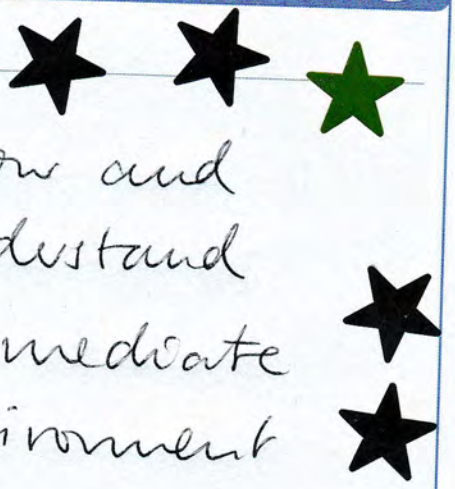
Detail No new materials to be processed - all new construction to be built from recycled & reused materials.

GAME CHANGER Table number 5

Title: Behavioural focus

Detail

Quantify selection and decisions; understand patterns that mediate btw. built environment and health, energy etc. outcomes



GAME CHANGER Table number 5

Title: HEALTHY NUTRITION

Detail

CONNECTING HOUSEHOLD WITH HCPS TO PROVIDE CONSTANT FLOW OF HEALTH PARAMETERS TO HOSPITAL/GP WITH POSSIBILITY TO AUTO/SENSOR DATA COLLECTION FROM HOME.

GAME CHANGER Table number 6

Title: FUNDING.

Detail

Need for a funding system that integrates all relevant disciplines [Research Council Silos need breaking down]

- Issues in the Built Envt are multi dimensional & need a similar funding response.

GAME CHANGER Table number 6

Title: NEW SENSORS FOR BUILT ENVIRONMENT

Detail

NEXT GENERATION SENSORS WITH ADDED INTELIGENCE ~~LEADING TO OPTIMAL TRADE-OFF BETWEEN~~ FOR IMPROVED ~~CONTROL IN THE~~ MANAGEMENT OF THE BULT ENV. UNDER BOTH EVERYDAY CONDITIONS (EFFICIENCY) AND FAULTY CONDITIONS (EARLY WARNING SYSTEMS)

GAME CHANGER Table number

Title:

Detail

Effective exploitation of data

GAME CHANGER Table number

Title: PROACTIVE BUDGETS.

Detail

PROVIDING SIGNIFICANT PUMP-PRIMING FUNDS TO COVER INNOVATIVE CHANGES THAT CLEARLY DEMONSTRATE SAVINGS IN THE MEDIUM-LONG TERM — OPPOSITE TO CURRENT REACTIVE TO MOVE BEYOND SHORT TERM INITIAL BUDGETS.

GAME CHANGER Table number

Title: Waste at household & community level

Detail

— waste without water

— movement or treatment on site

GAME CHANGER Table number

Title: Built Env - soil water interaction

Detail

This basic knowledge is not quite available but affect many built environ performances

GAME CHANGER Table number

Title: ★ ★

Detail

Inclusive and accessible built environments that are responsive to all people inc hidden disabilities.

GAME CHANGER Table number

Title: Birth rates worldwide too low

Detail

What happens if birth rates decline globally to significantly less than 2.0 per couple?

– leading to massive depopulation

GAME CHANGER Table number

Title: WAR

Detail

How Self-Sufficient are we?

What is our redundancy period if war broke out tomorrow? or in a decade? What are we not self sufficient in and currently lacking in dependence of our systems to? Energy? Water?

GAME CHANGER Table number

Title:

Detail

Pure & grey water systems at the household, commercial building scale.

GAME CHANGER Table number ?

Title:

Detail

Building only allowed on Brown spaces
or
Building promoted on Green spaces & implications for blue/green infrastructure

GAME CHANGER Table number

Title: Application of unlocking of unconventional data

Detail
- unconventional data
- citizen science
- background noise in data analysis -> particularly important in data constrained areas

GAME CHANGER Table number

Title: ~~Autonomous vehicles~~ ~~Automation~~ Autonomous vehicles

Detail

Could have considerable impacts on the nature of mobility and lifestyles / work

GAME CHANGER Table number

Title: Systemic greening of built environment

Detail

GAME CHANGER

Table number ?

Title:

Detail

Data security - an issue
- who has access to our smart cities and smart homes and smart infrastructure